Research Report 1199

EVALUATION OF THE SINGER NIGHT VISUAL SYSTEM COMPUTER-GENERATED IMAGE DISPLAY ATTACHED TO THE UH-1 FLIGHT SIMULATOR

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U. S. Army
Research Institute for the Behavioral and Social Sciences

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This report documents a 4-month evaluation of the Singer Computer-Generated Image, Night Visual System Independent Research and Development (IR&D) Display, attached to the UH-1 Flight Simulator. An instructor pilot evaluation of the system rated it acceptable for further tests, and a transfer of training study was run with Initial Entry Rotary Wing (IERW) students as subjects. Five night maneuvers were taught in the simulator and transferred to the helicopter. Trials to criterion and instructor ratings of performance were compared for experimental and control groups. No transfer effect was observed. next page

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cont. Problems incurred in device integration and test management are discussed and recommendations are made for alterations for further tests.

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Flight Simulation

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FOREWORD

The Army Research Institute Field Unit at Fort Rucker, Ala., provides timely support to the U.S. Army Aviation Center (USAAVNC) in the area of aviation training research and development. This research report documents work performed as a part of the Field Unit's Flight Simulation Work Unit research efforts in designing and conducting studies to evaluate helicopter simulator systems and subsystems for training suitability.

The entire program of aviation training research and development is responsive to the requirements of Army Project 2Q763743A772, Aircrew Performance in the Tactical Environment, and the Directorate of Training Developments, USAAVNC, Fort Rucker, Ala.

CPT Jack Davis of DTD, USAAVNC, served as monitor for this collaborative effort between USAAVNC, the simulator manufacturer, the ARI Field Unit, and the Project Manager for Training Devices. The instructor pilots from the Department of Undergraduate Flight Training, USAAVNC, were CW2 David Broadnax, CW2 Carol Courtney, CW2 Douglas Joyce, and CW2 Tom Adkins. CPT Dana Young, DRTM, USAAVNC, assisted in coordinating efforts to obtain subjects. SFC Floyd Ingram and SSG James Parker served as UH1FS console operators, and Mr. Mike Stephenson served as programer.

Joseph Zeidner

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EVALUATION OF THE SINGER NIGHT VISUAL SYSTEM COMPUTER-GENERATED IMAGE DISPLAY ATTACHED TO THE UH-1 FLIGHT SIMULATOR

BRIEF

Requirement:

To evaluate the suitability of the Singer night visual system computer-generated image display for integration with the UH-1 Flight Simulator for training.

Procedure:

Three evaluations were made over a 4-month period. In the first, four qualified contact instructor pilots conducted a formal rating of the capability of the system to accomplish each night contact maneuver contained in the Flight Training Guide. Next, 14 student pilots were trained in the simulator on five night contact maneuvers and performance was compared to seven control student pilots in a transfer of training study. An informal evaluation, using instrument instructors, was conducted to determine the device's capability to enhance instrument approach to landing.

Findings:

Instructor pilots rated the device acceptable for training, although there were notable deficiencies in visual cuing as well as in UH1FS flight characteristics after integration of the NVS.

There was no transfer effect, measured either by trials to criterion or instructor ratings of performance, on the student pilots.

The device was acceptable as an adjunct to instrument approach training.

Utilization of Findings:

Recommended modifications to hardware and further evaluations, sampling pilot performance at different points in the student curriculum, are necessary before judgment can be conclusive as to the suitability of the night visual system display in the training program. Therefore, it was decided not to procure a night visual system for the UH1FS.

EVALUATION OF THE SINGER NIGHT VISUAL SYSTEM COMPUTER-GENERATED IMAGE DISPLAY ATTACHED TO THE UH-1 FLIGHT SIMULATOR

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INTRODUCTION

The Army has increased its emphasis on synthetic flight training in the undergraduate initial entry rotary wing (IERW) course, the graduate training and transition courses, and in maintenance of instrument proficiency of its rated aviators. Helicopter simulators under development are scheduled to have complete six-degree-of-freedom motion systems and camera model board, closed circuit television visual displays. At present, the Army's UH-1 Flight Simulator is an instruments-only device with no out-the-window visual display. The UH-1 Flight Simulator has been successful from an instrument training point of view, and it was deemed desirable to investigate the possibility of increasing the device's training utility by attaching a visual display device to provide for night contact flight training.

A Letter Requirement (LR) was written by the U.S. Army Aviation Center and forwarded to the Project Manager for Training Devices (PM TRADE). Potential sources for night visual displays were invited to provide a visual system for evaluation with no contractual obligation to the government or the manufacturer. As a result, the Singer Company, Simulation Products Division, agreed to provide their APO Night Visual Calligraphic Independent Research and Development Product Improvement System for evaluation. This report documents the evaluation of that system.

Objective

The objective of the evaluation was to determine the suitability of the Singer Night Visual System (NVS) computer-generated image display, which was integrated with the UH-1 Flight Simulator for training.

Procedure

Two approaches were used to evaluate the NVS. In the first approach, four assigned instructor pilots were given thorough orientations and training in the device. Each was then asked to complete a comprehensive rating of the device's capabilities to accomplish the maneuvers described in the Flight Training Guide. The second approach to the evaluation was a transfer-of-training study using IERW student pilots.

Results

In the first evaluation, the instructor pilots rated the device suitable to accomplish most of the maneuvers listed in the Flight Training Guide.

In the second evaluation--the transfer study--comparisons were made of the number of trials to reach criterion performance and instructor ratings of performance for those trained in the simulator and those who received helicopter training in five selected maneuvers. There was no evidence of any increase in skill as a function of simulator training.

Conclusions

The following conclusions were reached, based on the two evaluations.

1. Instructor pilot ratings of the NVS/UH1FS showed the system acceptable for further training, but there were definite deficiencies in the visual display scene content that precluded activities such as maintaining ground track and judging distances and altitudes.

2. Window location of the side window display, coupled with a narrow field of view, required an adjustment in the simulator training and altered the method of instruction in some basic maneuvers.

3. Maneuvers requiring considerable out-the-window visual search, such as the night approach, were more difficult to accomplish and yielded greater variability than maneuvers in which outside referents were not required.

4. Hardware reliability caused evaluation management problems at the outset, and the general problems attendant on integration of a visual display with an instrument-only flight simulator were formidable.

5. On the basis of the data collected, the tested device was judged not suitable for training night contact helicopter maneuvers. However, before a definitive statement is made concerning the suitability of night visual system displays in such an application, hardware improvements and appropriate sampling of students in a different phase of training are recommended.

Recommendations

The following recommendations were made, based on the evaluation of the NVS/UH1FS.

1. The cockpit environment should be improved by eliminating the black light-shield curtain, devising a door seal to exclude stray light, and improving the ventilation.

2. The right window location should be empirically determined.

3. The eye height should be adjusted to yield a perceptually correct perspective, in focus.

4. The front window display technique should be further explored to yield a display that could rotate, so that the ground could be seen on approach.

5. Surface texture should be improved.

6. Scene luminance should be improved. Techniques such as brightening the entire surface of the display should be explored.

7. Measurements should be made to determine whether a lag exists in the visual system relative to the motion system and, if so, the duration of the lag.

BACKGROUND

The Army has increased its emphasis on synthetic flight training as an adjunct to regular training in the undergraduate initial entry rotary wing (IERW) course, the graduate training and transition courses, and in maintenance of instrument proficiency of its rated aviators. Helicopter simulators under development are scheduled to have complete six-degree-of-freedom motion systems and camera model board, closed circuit television visual displays. But at present, the Army's UH-1 flight simulator is an instruments-only device with no out-the-window visual display. Because the UH1FS has been so successful from an instrument training point of view, it was deemed desirable to increase the device's capability, if possible, by attaching a visual, out-the-window display.

Several problems arise in connection with the addition of a visual display to the UH1FS. The physical hardware limitations of the UH1FS and the lack of space in the building in which the UH1FS is housed preclude the attachment of a camera model board visual system. Alternative visual displays are point light source and transparency systems, open-loop movies, semi-closed loop (VAMP) movies, computer-generated image (CGI) displays, flying spot scanner-transparency systems, laser/holographic displays, and hybrid systems consisting of two or more of the basic approaches (Smode, 1972). State-of-the-art and physical limitations ruled out the basic approaches with the exception of CGI systems. Day color CGI has been rejected in the past because of state-of-the-art, particularly for terrain flight levels. But night-only calligraphic CGI display systems are sufficiently advanced that it was plausible to consider attachment of such a system, particularly with an increased emphasis in night training of the Army aviator. In addition, physical limitations that limited the use of other systems did not seem to constrain the UH1FS for night-only CGI. Therefore, the evaluation of such a system to enhance the capability of the UH1FS was desirable.

As a result of the considerations cited above, a Letter Requirement (LR) for a night visual system (NVS) was written. This LR justified the evaluation on the basis of the increased emphasis on night training. It also specified that the CGI NVS should be integrated without major modification to the SFTS UH1FS, and that no degradation of present capabilities of the UH1FS should result.

The LR specified the principal characteristics of the device in terms of the number of windows, number of light points available, cycle rate, and acceptable flicker. In addition, the LR specified that the device would be capable of presenting runway texture, horizon glow, and moon reflections. The LR further stated that the device was expected to increase the capabilities of the UH1FS in the following:

1. Hovering and ground operations,
2. Effective transition from hovering flight to forward and/or reverse flight,
3. Night autorotation to touchdown,
4. Night takeoff and approaches to confined areas, pinnacles, and stagefield using T-bar lighting,
5. Capability to break out on instrument approaches and execute a landing to Standard A lighting.

The LR listed the following further requirements in order of priority:

1. Confined area landing and takeoff using T-bar lighting,
2. Stagefield maneuvers using T-bar and normal lighting,
3. Tactical cross-country flight using a minimum number of light points required for navigation and/or orientation,
4. Instrument approaches to Standard A lighting with visual landing,
5. Pinnacle takeoff and landing using T-bar lighting,
6. Night formation flight,
7. Night military ground handling and parking procedures.

As a result of the LR, letters were sent to four firms involved in CGI night visual systems as a first step in obtaining demonstration models for evaluation. The letter invited the firms to demonstrate the capabilities of their systems on the UH1FS, without contractual obligation on the part of the government or the contractor.

The potential contractors were provided with the capabilities and priorities established in the LR, a milestone schedule, and data handouts on the characteristics of the UH1FS. In response to the invitation, the Singer Company, Simulation Products Division, agreed to participate in the evaluation.

This report presents the results of the evaluation of the Singer Night Visual System attached to the UH1FS. The evaluation was conducted during the period 27 June 1976 through 1 October 1976.

SIMULATOR SUBSYSTEMS DESCRIPTIONS

Visual Device Description

The visual system evaluated in this study was the APO Night Visual Calligraphic Independent Research and Development (IR&D) Product Improvement System, a nomenclature assigned by the Singer Company. It was a three-window display with two forward windows centered laterally in front of the pilot and copilot and extending from 18.5° below the eyepoint to 10° above the eyepoint. One window was fixed to the right side as close to the front window as possible, and extended from 5° above the horizon to 23.5° below the horizon.

The system was originally intended to simulate five flight regimes: the confined landing area, stagefield landing area, a tactical cross-country flight, instrument approach to Standard A lighting, and a pinnacle landing area.

System specifications for the confined area were developed by Singer.[1] Some modifications to these specifications were required and were incorporated on the job.

The confined landing area ground surface was 100 meters square and had a greenish ground texture. A vertical surface 10 m high joined the ground surface along the upwind edge and served as a barrier. This barrier surrounded the confined landing area, and the horizon was not visible below 10 m above ground level (AGL). The upwind and downwind barriers were illuminated and, after preliminary trials, it was necessary to imbed several red lights at varying heights above the ground to provide altitude cues for landing and takeoff. A Maltese cross was also placed on the ground surface to provide a drift-sense cue.

In order to provide visual cues for rate of closure to the confined landing area, it was necessary to add three light panels, in a staggered sequence, on the short-final approach.

The configuration for the stagefield included a landing lane, a parking ramp, and lights. A tower, constructed of a series of light chains, was added to the scene to provide an altitude cue for landing.

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[1] Systems specifications described were extracted from the Systems Specifications provided by Singer Company.

The landing area included an inverted Y, 1 red and 1 green threshold, 40 green taxi lights, and a green and white rotating beacon.

Runway texture simulated flat concrete with 6-in. edge lines, a pad with a white 60-ft. Maltese cross at each end of the runway, and a 2-ft. white square in the center of the lane. No texture appeared outside the runway or taxi areas, and the systems called for all surfaces and markings to be visible at least 30.5 m ahead of the helicopter.

The specifications also called for a tactical cross-country flight representing 50 nautical miles. In addition, approximately 100 white lights at each of two towns near the edges of the flight area and an additional 1,800 white and red lights spread randomly over the remainder of the area were provided.

A pinnacle landing area was constructed with a ground surface 100 m x 100 m in area. This flat surface was 30 m above the surrounding ground level. A vertical surface 100 m wide and 30 m high was placed from the approach edge of the landing area and extended downward to the surrounding terrain level, giving the appearance of a landing shelf.

UH1FS Description

The flight simulator used for this evaluation was the UH1FS. It is a simulator system consisting of a complex of four simulated cockpits driven by a single digital computer system. Each cockpit is mounted on a five-degree-of-freedom cascade motion base. A central instructor station is provided from which training performance in all four cockpits can be controlled and monitored. The UH1FS is designed to simulate the cockpit configuration and the flight, engine, and system performance of the UH-1H helicopter. Each trainee station consists of a cockpit shell with appropriate equipment, control loading system, and environmental effects equipment, including the cockpit motion system and sound simulation equipment. A problem control panel and trainee information display panel are also included in each cockpit.

EVALUATION PLAN

The requirements and priorities established in the LR formed the basis for the design of the evaluation. However, additional available data affected the approach to the evaluation. One such factor was "Night Hawk," and it played an important role in developing the evaluation plan.

Night Hawk was the name given a series of exercises conducted at the USAAVNC to determine the feasibility of night training in all helicopter maneuvers, to include emergency procedures, and to ascertain training requirements necessary for the night qualification of instructor pilots in these operations. Official guidance in developing the plan of evaluation was to make maximum use of the solutions and lessons learned in Night Hawk.

In order to comply with the guidance concerning Night Hawk, an experienced Night Hawk instructor pilot (IP) was recruited to serve as advisor and chief pilot during the planning phase of the evaluation. Since the lessons learned in Night Hawk had not been incorporated in the USAAVNC IERW curriculum, this IP had the additional responsibilities of prescribing the maneuvers and, later, of developing the Flight Training Guide for the Night Visual System evaluation.

Approach

In general, two evaluations of the Night Visual System were accomplished. First, the instructor pilots were given a thorough orientation and training in the device. The first evaluation required instructor pilots to complete a comprehensive rating of the device's capabilities. The second evaluation was a transfer-of-training study, which was conducted using IERW students in a standard transfer-of-training paradigm.

Evaluation I: Comprehensive Instructor Pilot Rating

Because the NVS was unique to the Army's training experience, it was desirable to have a broad exposure of the device over several levels of aviator experience. This approach would assist in determining whether the device was suitable for training and whether it might be more appropriate to one level of experience than to another. Therefore, the first evaluation was designed to consider the NVS/UH1FS as a system and to determine whether or not it was capable of providing suitable simulation to accomplish the maneuvers specified in the Flight Training Guide.

Method

Evaluators. In order to determine the system's capability of accomplishing the maneuvers, four Night Hawk-qualified instructor pilots were assigned to the project. Each had extensive current experience as an instructor, and one was a Standardization Instructor Pilot. All were, therefore, thoroughly familiar with the requirements of Night Hawk and equally conversant with accepted instructor methods.

The instructor pilots had to be trained to use the UH-1 flight simulator as an instructional tool. In addition, they had to learn how to fly the Night Visual System/UH1FS. The instructor pilots worked with the console operators to learn the simulator Initial Condition Sets for the device and how to use the device as an instruction tool. In addition, the IP's had to attain a personal proficiency on all of the maneuvers. These IP's were required to accomplish the tasks with and without motion.

A special student evaluation check sheet was developed for this effort, and the instructor pilots were required to spend time in the simulator learning how to use the device and how to grade maneuvers with the pilot evaluation sheets. In addition, informal classes were conducted in grading procedures. A minimum of 5 hours of instruction and practice was used by each of the pilots to attain a personal proficiency on all of the maneuvers.

Flight Training Guide. The Flight Training Guide is a standard document for each course of flight instruction at the USAAVNC. It is divided into four sections and states in detail the flight training maneuvers and procedures to be taught in the course. For each maneuver the training objective is specified, the maneuver requirements are stated, the maneuver is analyzed, and some common errors are listed. Because the Guide is complete for the particular course of instruction, this evaluation required each IP to conduct an independent rating of the system on each maneuver in the Guide.

Rating Scale. An 8-point rating scale was devised for use by the IP's in rating the device. (A copy of the scale appears in appendix A.) The scale lists a maneuver by name and then expresses each of the maneuver requirements in terms of the best performance possible. Given this sentence stem, which describes the best possible performance, the IP was asked to determine how that stem described his performance of that maneuver in the simulator and to place a mark in the block that corresponded to the degree to which the stem described his performance.

Initially, the plan of test called for a study with and without motion. Two IP's rated the simulator on each maneuver with motion on, then made a second rating with motion off. The other two IP's followed the same procedure first with motion off, followed by motion on.

Results and Discussion

The system was judged to be suitable for the transfer experiment and thus for training. But some points in the data merit discussion.

The Flight Training Guide was prepared to instruct contact flight maneuvers and was applied to the UH1FS/NVS system, as previously discussed. Because the main interest was to determine whether the device could be used to train night contact maneuvers, no attempt was made to evaluate the NVS separate from the system.

The stems that described the maneuver elements were assumed to be of equal weight in contributing to the maneuver they describe. Therefore, to obtain an IP rating of each maneuver, IP ratings of the elements of that maneuver were averaged. The original plan for the transfer-of-training test called for instruction with motion on and motion off, and the IP's rated the system under both conditions. However, circumstances prevented the test under both conditions and the motion-on condition was used in the study. Consequently, data are reported for the motion-on condition only.

Table 1 presents the results of the instructors' ratings of each of the maneuvers on the 8-point rating scale.

The maneuvers were also ranked on the basis of the ratings. Ranks were computed for each rater, based on his score of the maneuver. These ranks were then summed for all raters.

The rank order in Table 2 shows the relative rank, with those maneuvers rated highest listed first and others following in a descending order of rank.

To determine the reliability of the ratings and the degree of accord among the raters, two statistics were computed: Kendall's coefficient of concordance (W), and the intraclass correlation (Seigel, 1956; Guilford, 1964).

Kendall's W was used to test whether the raters were using the same standards in ranking the maneuvers. The basic formula also included a correction for time. A W of .620 was obtained, yielding an obtained Chi Square of 49.602, which was statistically significant (X^2_{20} $p < .001$). These results are interpreted to mean that the raters were applying essentially the same standards in ranking the 21 maneuvers. It does not mean that the ordering is "correct" in an absolute sense. However, according to Seigel, the best estimate of the true ranks is the ordering of the sums of the ranks.

In order to determine the rater reliability, a two-way analysis of variance was computed on the ratings, and the intraclass correlation was computed from the analysis. Table 3 presents the summary of the analysis.

The results of the analysis of variance indicated statistically significant differences between raters and between maneuvers. These results are not surprising and can be taken to indicate that the raters did discriminate between maneuvers. In addition, one of the raters did tend to rate each maneuver lower than the others but he showed the same general trend in his rating of any given maneuver.

Table 1

Average of Maneuver Element Ratings

MANEUVER	INSTRUCTOR RATING (8-POINT SCALE) INSTRUCTOR: A	B	C	D
Hover Check	3.00	6.67	8.00	5.00
Takeoff to Hover	5.00	8.00	8.00	7.33
Go-No-Go Procedures	4.00	7.33	8.00	7.67
Landing from Hover	7.00	8.00	8.00	8.00
Hovering Turns	4.00	8.00	8.00	6.30
Sideward Hovering Flight	4.67	8.00	8.00	7.00
Rearward Hovering Flight	1.00	1.00	1.00	1.00
Night Takeoff	5.4	7.00	8.00	8.00
Straight & Level Flight	8.00	6.67	6.00	8.00
Level Turns	6.00	8.00	7.00	8.00
Climbing and Descending Turns	6.00	8.00	7.00	8.00
Decelerations	7.00	8.00	8.00	8.00
Night Approach	5.75	5.75	5.25	7.75
Shallow Approach	6.00	6.75	5.75	7.75
Simulated Hydraulic Failure	1.00	7.29	6.14	8.00
Night Standard Autorotation	6.75	6.75	6.5	8.00
Night Low Level Autorotation	6.50	6.00	5.25	7.75
Night Reconnaissance	3.40	3.40	3.60	6.40
Night Circling Approach	6.00	7.25	7.25	6.50
Night Confined Area	3.75	4.50	5.00	5.50
Night Pinnacle	1.00	1.00	3.25	2.00

Table 2

Rank Order of Maneuvers Based on IP Ratings

MANEUVER	RANK	SUM OF RANKS
Landing from Hover	1.5* (Tie)	72.50
Deceleration	1.5*	72.50
Level Turns	3.5*	61.50
Climbing and Descending Turns	3.5* (Tie)	61.50
Night Takeoff	5	57.00
Night Standard Autorotation	6	55.00
Takeoff to Hover	7	54.50
Straight & Level Flight	8	54.00
Sideward Hovering Flight	9	52.50
Go-No-Go Procedure	10	49.00
Hovering Turns	11	48.00
Night Circling Approach	12	46.50
Shallow Approach	13	43.00
Simulated Hydraulic Power Failure	14	41.50
Night Low Level Autorotation	15	40.50
Night Approach	16	34.50
Hover Check	17	32.00
Night Confined Area	18	18.00
Night Reconnaissance	19	17.00
Night Pinnacle	20	7.50
Rearward Hovering Flight	21	5.50

Table 3

Analysis of Variance for Ratings

Source	SS	df	MS	F	p
Raters	45.94	3	15.31	12.25	$<.01$
Maneuvers	253.22	20	12.66	10.13	$<.01$
Residual	75.24	60	1.25		
Total	374.40	83			

The computed intraclass correlation was .87. This result indicates that the average of the intercorrelations of the ratings is .87. According to Guilford (1964), if the intercorrelation of the raters is taken to be a reliability of ratings, then the typical reliability of a single rater's ratings is on the order of .87.

On the basis of the data it was concluded that the instructors were in agreement concerning the system's capabilities and that their ratings were reliable. The system was judged suitable for continuation of the evaluation. The raters' opinions of the visual system's capabilities and limitations are further explored in the general discussion section of this report.

Evaluation II: IERW Transfer of Training

The method chosen to determine the suitability of the Night Visual System for training was a transfer-of-training study using IERW students.

Objectives. The original test plan specified five objectives:

1. To compare transfer performance of IERW students trained with visual and motion simulation of night maneuvers with performance of those trained in actual aircraft;

2. To compare transfer performance of IERW students trained on night maneuvers in the UH1FS using automated instruction with that of IERW students trained in the UH1FS by instructor pilots;

3. To compare transfer performance of rated aviators not in flying assignments who are trained with visual and motion simulation of night maneuvers with performance of those trained in aircraft;

4. To compare transfer performance of rated aviators not in flying assignments who are trained with visual and motion simulation using automated instruction with performance of those trained in the simulator by instructor pilots, and to compare performance of both groups with performance of those trained in the aircraft;

5. To obtain quality assurance data on the NVS.

Two factors caused the original objectives to be revised for this evaluation: (a) a shortage of qualified instructor pilots precluded the testing of the rated aviators; and (b) computer rounding techniques prevented the exact replication of a maneuver, and as a consequence, the automated demonstration tapes could not be constructed. Therefore, the objectives for this evaluation were limited to objectives 1 and 5 above.

Method

Subjects. Subject student pilots were volunteers from Officers and Warrant Officer Candidates (WOC's) in the resident IERW classes. Each class is divided into a section of officers and a section of WOC's. In any given week, the officers may fly in the morning and receive academic training in the afternoon, while the WOC's receive academics in the morning and flight instruction in the afternoon. The following week the schedule is reversed. To select subjects, a roster of officers and WOC's was obtained for each class, 10 names were selected from each roster via a table of random numbers, and these individuals were assembled according to section. The test was explained, and 8 volunteers were obtained from the pool of 10 subjects.

Volunteers were necessary because the curriculum flow did not allow time to conduct this study. The desirability of obtaining students prior to their exposure to night training made the last 2 weeks of instrument qualification the best available time. They had completed an academic block and were flying only half-days. Because checkrides are usually given during this 2-week period, many subjects would have considerable free time if they had completed academics and had had a checkride the first week. In some cases a subject was scheduled for a checkride in the second week and was not available for the evaluation. Since there was the possibility of disrupting a student's training activity but there was no provision for any type of remedial training, the Department of Resident Training Management (DRTM) felt it would not be expedient to assign students to serve as subjects.

Complete data were obtained on 21 subjects, and partial data were collected on a larger number. Equipment malfunction, weather, and administration difficulties prevented collection of a complete set of data on all subjects.

Performance Assessment. The standard grade sheet used in the courses of instruction was deemed unacceptable for this study. The preferred method was to grade performance as objectively as possible and to exclude categories that called for subjective judgments.

The first step in developing the grade sheet was to identify each maneuver to be trained in the simulator and the aircraft. Next came identification of maneuver elements in each maneuver that were critical to that maneuver. Most of this information is specified in the Flight Training Guide and it was therefore the major source for such information.

After identifying the maneuver and its elements, an index of desired performance was specified for each element; where feasible a band of acceptable performance around that index was identified. That is, some maneuvers were scored in a dichotomous fashion, e.g., yes or no, while others received a numerical score.

Next, for those elements where number assignment could be done, the index of desired performance, identified as "correct" performance, was assigned the number 3. For example, if the student flew the correct altitude on a given trial, he received a 3 for altitude. If altitude was low but within acceptable limits, a score of 2 was assigned. If altitude was low and outside the limits, the score of 1 was assigned. Likewise, high, acceptable performance was assigned a 4 and high, unacceptable performance earned a 5.

For all maneuver elements, a subject would receive either a number or Y for yes, N for no, R for rough, or S for smooth.

In addition to the above scale, the IP was also required to rate the student's last simulator flight, first UH-1 flight, and last UH-1 flight, using a 12-point scale adapted from Reid (1975).

The performance assessment grade slip was used to determine both the number of trials to reach criterion performance and the rating of performance at that criterion point.

Each IP was given a draft form of this grading slip for trial. He was requested to rate performance after each trial of each element of the maneuver. After the trial period, a conference was held with the IP's to discuss refinement of the grade slip. The IP's then identified, on each maneuver, the element or elements critical to the maneuver. "Critical" was operationally defined as that element that can be identified as critical to the success or failure of the maneuver. The pilots were successful in paring the list of elements to those they thought must be done correctly, within limits, in order to execute the maneuver successfully. (The grade sheet appears in appendix B.)

Maneuvers Tested. The maneuvers selected for inclusion in the NVS evaluation were extracted from a list of maneuvers recommended for a 12-hour night transition course for IERW students. Additional selection factors were the capability to perform the maneuver in the simulator and in the aircraft, the time available, and the availability of an adequate number of instructor pilots. Based on these factors, the following list of maneuvers was selected for evaluation in this study.

1. Night takeoff and climb,
2. Night cruise,
3. Night approach to stagefield to an inverted Y,
4. Night approach to a confined area (simulator only) (a night circling approach to an inverted Y was used as a substitute for the confined area in flight tests),
5. Night autorotation,
6. Instrument approach and breakout to landing to Standard A lighting (instrument IP's only).

Experimental Design. The diagram below depicts the final experimental design of this test.

Vehicle	Method of instruction	Flight sample
UH-1 flt simulator	Instructor pilot	IERW
UH-1H helicopter	Instructor pilot	IERW

Procedure. Six of the eight subjects selected from each section were used while two were alternates. Four of the six received simulator training while the other two were the controls, receiving helicopter training only. Because two sections comprise a class, two students from a section would receive simulator training in the morning, and two from the other section would receive it in the afternoon. Thus, four students were trained each week in the simulator; these were tested, along with the control subjects, in the transfer task.

One instructor pilot was responsible for instructing one student in the simulator and then for instructing two students in the aircraft--one previously trained in the simulator and one not previously trained. The IP was requested to instruct a different student in the aircraft from the one he had in the simulator.

Simulator Instruction. Simulator instruction was on a proficiency advancement basis. Instructional periods for the simulator were of approximately 1 hour and 20 minutes duration, beginning on Monday of each week. Upon reporting, a student would receive a brief orientation and move to the simulator. Actual instruction was in the sequence indicated on the grade sheet and was on a proficiency basis. Competence in a maneuver was operationally defined as two successive repetitions of a maneuver with a score of 2, 3, or 4, that is, within tolerances. Unique features of the simulator were used to expedite the training. Rather than teach an entire traffic pattern as is done in the helicopter, the IP's were requested to use Initial Condition Sets. Thus, in training night takeoff and climb, the helicopter was established on the lane and the maneuver was executed. Upon reaching a climbing attitude on altitude to turn downwind, the IP would freeze the device, return to the predesignated Initial Condition Set on the lane and practice the takeoff again. Students would then progress to the next graded maneuver upon reaching criterion. This served to save time and concentrate the learning experience on a single task at a time.

When a student reached criterion, the IP would usually fly some complete maneuver patterns such as the traffic pattern. Then the student's performance was rated on the 12-point performance scale.

On Thursday and Friday nights of the same week in which simulator training was accomplished, the simulator and aircraft-only students reported to the helicopter for IP assignment and instruction in the aircraft.

A stagefield, reserved for the training, was set up with appropriate air traffic control personnel and with minimum lighting to include the inverted Y.

In order to establish a baseline for performance and to determine the effect of prior simulator training, the IP's were requested to demonstrate a maneuver once and then to allow the student to try the maneuver with no additional instruction. The IP scored the maneuver and rated the performance on the 12-point scale. Then the student was given additional instruction as necessary to reach criterion. The flight on which criterion was reached was rated on the 12-point scale.

Results and Discussion

On the basis of the data collected, the system did not demonstrate transfer of training when used on the samples described. These data are discussed briefly in this section and in greater detail in the general discussion section.

The two basic forms of data collected during the evaluation were trials to criterion and instructor ratings of pilot performance. During the graded training sessions the IP recorded the number of trials required to reach the criterion of two successive trials with all maneuver elements within acceptable limits, and he also rated the student's performance on the 12-point rating scale.

Trials to Criterion. The data were analyzed with a Randomized Block analysis of variance as described by Kirk (1968). Cochran's test was computed and the data were heterogeneous. Therefore, a reciprocal transformation was applied to the data. Table 4 presents a summary of the analysis of these data.

Table 4

Analysis of Variance of Simulator Trials to Criterion

Source	SS	df	MS	F	p
Maneuvers	.1102	4	.0276	7.6667	<.01
Subjects	.1285	13	.0099	2.7500	<.01
Residual	.1824	51	.0036		
Total	.4211	68			

One score in the data was missing, and that datum point was estimated using accepted statistical technique. One degree of freedom was subtracted from the residual error term and from the total degrees of freedom as a result.

The data showed that there were significant differences between the maneuvers, indicating that it was easier to reach a criterion level of performance on one or more maneuvers. Tukey's HSD statistic was calculated to make pair-wise comparisons among the means. It was found that the mean trials to criterion for the night approach and the night autorotation were significantly larger than for the takeoff. In addition, learning to fly the cruise maneuver required significantly fewer trials than the night approach, night autorotation, or night circling approach.

Table 5 contains the mean scores for maneuvers. The data analyzed were reciprocals, but the means in Table 5 are those computed from the original data and are thus presented to avoid confusion in interpretation.

Table 5

Mean Trials to Criterion for Simulator-Trained Students

Maneuver				
Takeoff and climb	Cruise	Night approach	Night autorotation	Night circling approach (confined area)
3.21	2.64	5.71	5.64	3.93

There were also significant performance differences among the student pilots. However, this result was interpreted as indicating individual differences in learning rates and was not pursued with further analysis.

A major determiner of the transfer effect was the comparison of the number of trials the helicopter-trained group required to reach criterion performance with the number of trials required by those who were trained in the simulator first.

A split-plot factorial design analysis of variance was computed on the data. The Cochran test for homogeneity of variance was not significant. The analysis of variance least-squares solution was computed on the data because of planned unequal size subgroups. Table 6 presents a summary of the analysis.

Table 6

Analysis of Variance of Aircraft Trials to Criterion

Source	SS	df	MS	F	p
Between subjects	31.83	20			
Type of Training	1.55	1	1.55	.97	NS
Subjects Within Groups	30.28	19	1.59		
Within Subjects	82.80	84			
Maneuvers	8.62	4	2.16	2.35	NS
Type Training x Maneuver	3.89	4	.97	1.05	NS
B x Subjects Within Groups	70.29	76	.92		
Total	114.63	104			

The results of this analysis indicate no significant differences between those trained in the simulator and those trained in the aircraft only. In addition, there was no significant difference between maneuvers in terms of trials to criterion.

It is also informative to look at the variability in each of the maneuvers. Table 7 shows the variability in trials to criterion performance on maneuvers performed by those trained in the aircraft and those trained in the simulator.

Table 7

Trials to Criterion Variance of Maneuvers in Helicopter

	Maneuver				
	Takeoff & Climb	Cruise	Night Approach	Night Autorotation	Night Circling Approach
Helicopter Training Only	.24	1.56	.90	.40	1.23
Simulator Training	1.14	.55	1.49	2.10	.42

Although there were no significant differences among these variances, Table 7 does point to some peculiar patterns in the distribution of the variances, particularly in the night approach and the night autorotation. An explanation of these results is, at best, conjecture.

Instructor Ratings. In assessing performance it was reasoned that the case could arise in which there was no statistical difference in trials to criterion, yet the instructor could determine that there were qualitative differences which, if quantified, could indicate significant performance differences. To determine this, the ratings assigned by the IP's on the first flight in the aircraft were analyzed. A split-plot factorial design with a least-squares solution was used in the analysis. Cochran's test for homogeneity indicated that the assumption of homogeneity could not be accepted. A square-root transformation of the original scores was applied to the data. Table 8 presents a summary of the analysis of variance of ratings.

The summary indicates no statistically significant difference in ratings assigned to those who had simulator training and those who did not.

Table 8

Analysis of Variance of First Helicopter Flight Ratings

Source	SS	df	MS	F	p
Between Subjects	10.90	18			
Type of Training	1.07	1	1.07	1.84	NS
Subjects Within Groups	9.83	17	.58		
Within Subjects	12.36	76			
Maneuvers	1.93	4	.48	3.20	<.05
Type Training x Maneuver	.22	4	.06	.40	NS
B x Subjects Within Groups	10.21	68	.15		
Total	23.26	94			

It appears that cruise might have a slightly higher rating than the other maneuvers, as indicated by the statistical significance of the maneuver effect.

The same rationale for rating the first helicopter flight was applied to the trial at which the criterion performance was attained. Table 9 presents a summary of the split-plot factorial analysis of variance of these rating data. A least-squares solution was also applied to these data to adjust for unequal subgroup size.

Once again, the data analysis shows no significant differences between ratings of those trained in the helicopter and those who received prior simulator training. Again, there was a difference in the ratings of the maneuvers, indicating that cruise received a higher rating. This is not a surprising result because cruise flight is probably the easiest maneuver to perform.

Finally, IP ratings having been obtained for the last simulator flight on each of the maneuvers and on the first and last helicopter flights on each maneuver, correlation coefficients were computed between each of the maneuvers to determine the trend of the student pilot's performance in the helicopter. Table 10 is a matrix showing the correlation of rating scores of the maneuvers in the simulator and those same maneuvers on first helicopter flight.

Table 9

Analysis of Variance of Final Helicopter IP Ratings

Source	SS	df	MS	F	p
Between Subjects	134.95	18	7.50		
Type of Training	3.13	1	3.13	.40	NS
Subjects Within Groups	131.82	17	7.75		
Within Subjects	128.33	76	1.69		
Maneuvers	26.89	4	6.72	4.89	.005
Type Training x Maneuver	7.94	4	1.99	1.45	NS
B x Subjects Within Groups	93.50	68	1.38		
Total	260.15	94	2.77		

Table 10

Correlation Between Ratings of Last Simulator and First Helicopter Performance

	First Helicopter Flight				
Simulator	Takeoff & Climb	Cruise	Night Approach	Night Autorotation	Night Circling Approach
Takeoff & Climb	.03				
Cruise		-.14			
Night Approach			.45		
Night Autorotation				-.30	
Night Circling Approach					-.27

Each correlation coefficient was tested with Fisher's t to determine whether it differed significantly from zero, the expected population correlation. None was significant. This result is interpreted to mean that no rating in the simulator could be used to predict reliably the rating on the first helicopter flight.

In a similar manner, coefficients were computed for the last simulator flight and the last helicopter flight. Table 11 presents the results.

Table 11

Correlation Between Ratings of Last Simulator and Last Helicopter Performance

	Last Helicopter Flight				
Simulator Flight	Takeoff & Climb	Cruise	Night Approach	Night Autorotation	Night Circling Approach
Takeoff & Climb	.00				
Cruise		.13			
Night Approach			-0.06		
Night Autorotation				-.56	
Night Circling Approach					-.14

Again, using Fisher's t, no coefficient differed significantly from zero.

To determine if trials to criterion in the simulator could be used to predict subsequent trials required in the helicopter, a correlation coefficient was computed on each of the maneuvers. Table 12 shows the results. None of the correlation coefficients in Table 12 was statistically significant from zero.

Table 12

Correlation of Simulator Trials to Criterion and Helicopter Trials to Criterion

Simulator Trial	Helicopter Trial				
	Takeoff & Climb	Cruise	Night Approach	Night Autorotation	Night Circling Approach
Takeoff & Climb	-.01				
Cruise		-.09			
Night Approach			.01		
Night Autorotation				.01	
Night Circling Approach					-.42

On balance, the results of this evaluation of the NVS/UH1FS system did not demonstrate reliable effects on the students who received training in it when their performance was compared to matched subjects with no simulator training.

An analysis of variance was computed on trials to criterion performance, as indicated previously, and no significant differences between simulator and helicopter-trained students were detected. In computing correlation coefficients, however, it was noted that those trained in the simulator exhibited more variability in trials-to-criterion scores in the simulator than in the aircraft on both the night approach (6.68 to 1.47) and the night autorotation (9.32 to 2.09). The data are not conclusive. A corresponding examination of the variability of those two maneuvers for those with helicopter training showed variances of .90 for the night approach and .48 for the autorotation. Because the overall tests showed no reliable differences, these findings were not pursued. There may be some disruption in the simulator on these two maneuvers that does not occur in the aircraft; yet it was not of sufficient effect to influence the later transfer performance. This effect is discussed in more detail in the Discussion section.

Finally, the question was asked whether the simulator trials to criterion and the final simulator performance rating could be used to predict trials to criterion in the transfer task. A multiple correlation coefficient was computed for these variables on the takeoff and climb, cruise, night approach, and night autorotation. Table 13 presents the data in terms of the coefficient of correlation, the coefficient of multiple determination for the four maneuvers, and the index of forecasting efficiency. The multiple correlation coefficient (R) shows the relationship of the two predictors to the criterion task. The coefficient of multiple determination (R^2) is an index of the amount of variance in the transfer trials to criterion that can be accounted for by the variance in the predictor variables taken together. The index of forecasting efficiency (E) is the percentage reduction in errors of prediction by reason of the multiple correlation. In these cases, E indicates in the case of the night approach, for example, that predicting the score of night approach performance in the transfer task by means of the multiple R is on the order of 8% better than using a knowledge of the mean scores of the night approach trials-to-criterion data. However, as shown by the R^2, much of the variance remains unaccounted for by the relationship. As a consequence, predicting the transfer performance on these four tasks would be done with low confidence in the predicted outcome.

Table 13

Multiple Coefficient of Correlation, Coefficient of Multiple Determination, and Index of Forecasting Efficiency In Predicting Transfer Trials to Criterion from Simulator Trials to Criterion and Rating

	Maneuver			
Index	Takeoff & Climb	Cruise	Night Approach	Night Autorotation
R	.52	.57	.39	.22
R^2	.27	.33	.15	.05
E	15%	18%	8%	3%

Evaluation III: Informal Evaluation of Instrument Approach Capability

To assess the system's ability to enhance instrument approach to Standard A lighting, the original plan was to develop a series of approaches and have instrument pilots assess the suitability of the device. To this end, software for a front and back course instrument landing system (ILS) approach was developed for Goldberg stagefield, as it was represented on the NVS, and an approach plate was drawn to show the approaches.

Circumstances, time, and personnel availability prevented a formal evaluation of this capability. Anecdotal evidence obtained from Flight Simulator Division personnel and other aviator personnel indicated that the capability to execute an ILS approach and breakout at several ceiling heights and visibility levels was satisfactory. This capability was judged to be suitable as an adjunct to the night instrument approach training. There were limitations to this capability, but they dealt primarily with the limitation of time in developing the software. Similar difficulties, experienced in the automated tapes, will be mentioned in the Discussion section.

DISCUSSION

In this further discussion of the total system evaluation, topics of a general nature are treated, as they influenced the evaluation. Additional discussions are developed concerning the two major evaluations.

Although this evaluation was originally designed to be a suitability evaluation of the NVS, certain factors arose that tended to expand the scope of the effort. As a result of adding the visual display, many discrepancies in the handling characteristics and instrument readouts of the UH1FS were noted; obviously, attaching the NVS placed on the system requirements that did not exist for an instruments-only simulator. This led to several problems, for example, the requirement to develop the hover mode. Although simulated hover in the UH1FS for instrument training was unnecessary, it is a prime requirement for contact flight. Similar problems were encountered during the software integration and some fixes were effected. There were sufficient handling qualities problems to warrant a delay in the original ready-for-training date.

The four instructor pilots were diligent in working with Singer engineers to correct deficiencies caused by adding the visual display. Some examples of difficulties follow, to give perspective to the problem of integrating the NVS.

One of the first difficulties was noted in the pilots' complaints about the "sensitive" collection pitch and the "bouncing" of the helicopter when attempting to land. This was characterized as a "trampoline" effect, caused by excessive flexion programed into the cross tubes.

The helicopter would also draft up and down. The draft was slow but noticeable and required constant adjustment of collective pitch. This was solved by increasing stability and dampening the aircraft when in ground effect. However, this led to additional problems, namely an increase in acceleration, which caused a "float" when making an approach or autorotation. A solution was to devise an acceleration parameter for takeoffs and a separate deceleration parameter for vertical descent. However, when these changes were made, the computer approached capacity and no additional corrections in those parameters could be made.

Additional problems in RPM needles in autorotation led to other adjustments, either in the software or on the part of the pilots who had to accommodate to the changes.

Because of the limited field of view, approaches tended to be shallower than normal throughout the evaluation. At the beginning, the IP's identified this as a problem of sufficient magnitude that a centerline had to be constructed, edge markings enhanced, and six large stripes added to the lane.

Altitude judgments were difficult, at low altitudes in particular. A tower was added to the stagefield to aid in altitude judgment for approaches and helped solve problems in altitude judgment and rate of closure judgments.

One particular problem to which the pilots had to accommodate was hover altitude. Although the eye height was calculated to be correct, perceptually it gave the appearance of being too high. Attempts to adjust this led to a kind of de-focus; the IP's decided they would rather have the simulation in focus at a higher altitude and explain it as a training problem if a question arose.

The confined area had to be modified. On approach, the horizon would be lost near 30 ft. AGL; then, because of the uniformity of the visual scene, disorientation and a hard landing would usually result. Two vertical rows of lights were added to the barrier, and a rear barrier was also added to the scene to assist in judging rate of closure.

Additional recommendations and improvements could have been made--but those actually made were required, in the estimation of the IP's, to reach a minimal acceptable level for training.

In addition to the necessity for the fixes described above, considerable difficulty was noted with NVS hardware reliability in the beginning portion of the evaluation. The system was released by Singer for the test on 27 June 1976, but through the first 2 weeks, training could only be attempted and was seldom completed. Consequently, training ceased, and Singer was requested to make repairs. The suitability test was begun again on 19 July, and with minor exceptions the reliability improved considerably. A complete NVS system maintenance log was kept by Singer from 1 May 1976 through 9 December 1976, describing each failure and the corrective action taken. During the period of the evaluation, there were 32 recorded failures, caused primarily by electronic component malfunctions.

Instructor Pilot Evaluation

After the problems had been corrected, the IP's who had spent much time in the simulator were asked to conduct their evaluations. The results of these evaluations did conclude that the device was suitable for continued training, but several points merit further discussion.

The rating scale used by the IP's was developed with the intent of evaluating the device as a contact flight training device. As mentioned previously, the maneuver element descriptions were not designed to address visual factors only. Nevertheless, unless some pilot opinions and comments obtained after the evaluation are taken into account, some effects (or lack of effect) of the visual system are obscured.

Although hovering and other near-ground maneuvers were accomplished, one pilot felt that without lights to the front of the helicopter at a hover, altitude could not be maintained; this was attributed to the restricted field of view. This commend was typical and reflected a consensus of the pilots in that ground track was consistently rated low. Thus, although a maneuver was rated as acceptable, in those cases in which the cues were from out the window, the pilots felt the cues were insufficient. For example, if a takeoff and climb were rated high, it was because of the overall device capability, since the heading could be maintained via the RMI or other instruments. Indeed, this was the method required for many of the maneuvers.

The IP's found that not all maneuvers were simulated equally well. In addition to those maneuvers that simulated the aircraft with reasonable fidelity, the hydraulic power failure was simulated, but with low fidelity. That is, its response was unlike the response after a hydraulic power failure in the aircraft. Their evaluations further revealed that rearward hovering flight was not programed.

From the IP evaluation sheets, it is evident that the out-the-window display was less than adequate when required to provide cues such as the ground track, terrain for high or low reconnaissance, and maneuvers related to the pinnacle operation. Also, as pointed out previously, the restricted visual angle required a shallower approach than the pilots desired. Pilot comments indicated that the side window and chin windows in the helicopter were more useful to them than they had first realized, and lack of such displays caused an alteration in their instruction.

Finally, a factor that cannot be assessed but should be mentioned is the attitude with which the instructor pilots approached the task. At the outset they were somewhat antisimulation and expressed some concern about the amount of time required away from their duty assignments, but as they became involved in the process, they developed a more prosimulation attitude. There was a general expression of confidence in their work and a willingness to work longer hours to make the evaluation as successful as possible. This is to say that a bias would be hard to document, because what may have started as a bias against the device seems to have shifted to an extent that a leniency could have been reflected in the evaluation ratings. The criteria established by the instructors in rating the device seem to have been shared by all, as evidenced by the coefficient of concordance, but it is still not clear as to why the large number of high ratings resulted. The reasons could only be conjectured.

Transfer of Training Evaluation

The device was hypothesized to render a positive transfer effect. It did not, so further discussion is warranted.

Hampering of the transfer study at the outset by the equipment reliability has been discussed. But problems also arose in attempting to integrate the evaluation into the existing Aviation Center training program.

As has been mentioned, it was not possible to assign students to the evaluation, and consequently they were obtained on a noninterference basis. This difficulty, along with the shortage of time for the evaluation, had significant influence on the evaluation. The evaluation had an absolute deadline, after which the instructor pilots were to revert to their regular duties. Becuase of a concern to obtain and train as many subjects as possible, the method of grading performance was influenced.

Criterion performance had been discussed at length with the instructors, and they had agreed that two consecutive trials performed within acceptable limits, as defined by the grade sheet, would be a sufficient indicator of success. But with this as the referent, there was perhaps an insufficient capability to discriminate performance. More precise measures of discrimination might have demonstrated different results in the transfer study.

The amount of variability in the simulator training of students, which did not appear in the transfer task, could mean that there was some cue or activity in the simulator that disrupted performance in the simulator but was not of sufficient magnitude or duration to affect helicopter performance. On the other hand, such an effect could also be a result of lack of discrimination of performance by the instructors in the transfer task. At least one reason could be the lack of time for accomplishing that transfer task.

As mentioned previously, Thursday and Friday of each week were used for this training. The press of trying to train six to eight students to criterion on five maneuvers and return aircraft by scheduled return times probably led to discriminations that were less fine than usual, by otherwise dedicated instructors.

A related factor that increased the workload was the illness and loss of one instructor, with no replacement for the majority of the evaluation.

One factor that undoubtedly influenced the outcome of the study was the point in the student flow at which the students were obtained; additional study with the NVS might show a more appropriate time. The student pilots were obtained during the final stages of instrument training. They had not received any contact training in the UH-1. Furthermore, there is no requirement for the instrument instructor pilots to qualify these students in any maneuvers. Nevertheless, some usually teach their students to fly some contact maneuvers, including landings, while others do not. Thus, there was no positive control over the entire amount and type of experience accrued by the students. Obviously, other situations could yield a more appropriate test of the NVS. Such a reevaluation may be needed to make definite conclusions concerning the results. In addition, some time must be made available to explore the configuration of the NVS and to select a more appropriate time for undertaking the training. If these latter factors are remedied, an evaluation yielding conclusive recommendations could be made.

Miscellaneous

As time permitted, experienced aviators were invited to fly the system and their opinions were solicited. Almost without exception, those individuals who were older, who were not in flying assignments, or who had not flown in some time, reported nausea--in the words of one person, "I was deathly ill." This response is not uncommon, and previous reports have hinted that a possible cause is a lag in the onset of the visual system after the motion system response. These past experiences and the reasons for them indicate a need to measure the visual/motion system to determine whether a lag exists and, if it does, whether it is of sufficient magnitude to cause performance decrements.

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APPENDIX A

DEVICE RATING SCALE

	Fits Poorly 1	2	3	Intermediate Degrees of Fit 4	5	6	7	Fits Well 8
HOVER CHECK								
Can perform before-takeoff check perfectly.	[]	[]	[]	[]	[]	[]	[]	[]
Can perform control response check prior to leaving the ground perfectly.	[]	[]	[]	[]	[]	[]	[]	[]
Can perform center-of-gravity (CG) check prior to the helicopter leaving the ground perfectly.	[]	[]	[]	[]	[]	[]	[]	[]
TAKEOFF TO HOVER								
Can perfectly maintain altitude of 3 feet ± 1 foot.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain heading ± 10 degrees.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly limit drift to no more than 1 foot.	[]	[]	[]	[]	[]	[]	[]	[]
GO-NO-GO PROCEDURES								
Can perform hover check perfectly.	[]	[]	[]	[]	[]	[]	[]	[]
Can determine maximum allowable hover power (N_1) perfectly.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly determine if helicopter has sufficient power (N_1) to make takeoff.	[]	[]	[]	[]	[]	[]	[]	[]
LANDING FROM HOVER								
Can perfectly maintain heading ± 10 degrees.	[]	[]	[]	[]	[]	[]	[]	[]
Can limit drift to no more than 1 foot.	[]	[]	[]	[]	[]	[]	[]	[]
HOVERING TURNS								
Can perfectly maintain altitude of 3 feet ± 1 foot.	[]	[]	[]	[]	[]	[]	[]	[]
Can maintain position over pivot point perfectly.	[]	[]	[]	[]	[]	[]	[]	[]
Can maintain constant rate of turn (not to exceed 360 degrees in 15 seconds) perfectly.	[]	[]	[]	[]	[]	[]	[]	[]

SIDEWARD HOVERING FLIGHT	Fits Poorly 1	2	3	Intermediate Degrees of Fit 4	5	6	7	Fits Well 8
Can perfectly maintain altitude of 3 feet ± 1 foot.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain heading ± 10 degrees.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain groundspeed not to exceed brisk walk (approximately 5 knots).	[]	[]	[]	[]	[]	[]	[]	[]
REARWARD HOVERING FLIGHT								
Can perfectly maintain altitude of 3 feet ± 1 foot.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain heading ± 10 degrees.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain groundspeed not to exceed brisk walk (approximately 5 knots).	[]	[]	[]	[]	[]	[]	[]	[]
NIGHT TAKEOFF								
Can perfectly maintain altitude of 3 feet ± 1 foot (prior to effective translational lift).	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain heading ± 10 degrees.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain constant ground track.	[]	[]	[]	[]	[]	[]	[]	[]
When climb is established:								
1) can perfectly maintain 60/70 knots ± 5 knots.	[]	[]	[]	[]	[]	[]	[]	[]
2) can perfectly maintain rate of climb - 500 feet per minute ± 100 feet per minute after terrain clearance.	[]	[]	[]	[]	[]	[]	[]	[]
STRAIGHT AND LEVEL FLIGHT								
Can perfectly maintain altitude as directed ± 100 feet.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain airspeed 80/90 knots ± 10 knots.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain constant ground track.	[]	[]	[]	[]	[]	[]	[]	[]

LEVEL TURNS	Fits Poorly 1	2	3	Intermediate Degrees of Fit 4	5	6	7	Fits Well 8
Can perfectly maintain altitude as directed ± 100 feet.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain airspeed 80/90 knots ± 10 knots.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain constant rate of turn.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain heading ± 10 degrees on rollout.	[]	[]	[]	[]	[]	[]	[]	[]
CLIMBING AND DESCENDING TURNS								
Can perfectly maintain airspeed 60/70 knots ± 10 knots.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain rate of climb 500 fpm ± 100 fpm.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain rate of descent 500 fpm ± 100 fpm.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain heading ± 10 degrees on rollout.	[]	[]	[]	[]	[]	[]	[]	[]
DECELERATIONS								
Can perfectly maintain altitude ± 100 feet.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain airspeed minimum, 40/50 knots ± 10 knots and maximum 80/90 knots ± 10 knots. (40 KIAS minimum)	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain heading ± 10 degrees.	[]	[]	[]	[]	[]	[]	[]	[]
NIGHT APPROACH								
Can perfectly maintain entry altitude as directed ± 50 feet.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain entry airspeed 60/70 knots ± 5 knots.	[]	[]	[]	[]	[]	[]	[]	[]
Can maintain ground track perfectly.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain constant approach angle 8 to 15 degrees (Index angle 12 degrees).	[]	[]	[]	[]	[]	[]	[]	[]

	Fits Poorly 1	2	3	Intermediate Degrees of Fit 4	5	6	7	Fits Well 8
NIGHT SHALLOW APPROACH (RUNNING LANDING)								
Can perfectly maintain entry altitude as directed $\pm$ 50 feet.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain entry airspeed 60/70 knots $\pm$ 5 knots.	[]	[]	[]	[]	[]	[]	[]	[]
Can maintain ground track.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain constant approach angle 50 to 8 degrees (Index angle 7 degrees).	[]	[]	[]	[]	[]	[]	[]	[]
NIGHT SIMULATED HYDRAULIC POWER FAILURE								
Can perfectly maintain entry altitude - as directed $\pm$ 50 feet.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain entry airspeed - 80/90 knots $\pm$ 5 knots.	[]	[]	[]	[]	[]	[]	[]	[]
Can maintain ground track.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain approach angle - 5 to 8 degrees (Index angle 7 degrees).	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly attain touchdown point at first usable one-third of runway.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain touchdown speed - at or slightly above effective translational lift.	[]	[]	[]	[]	[]	[]	[]	[]
After touchdown - can perfectly maintain lane alignment.	[]	[]	[]	[]	[]	[]	[]	[]
NIGHT STANDARD AUTOROTATION								
Can perfectly maintain entry altitude as directed $\pm$ 50 feet.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain entry airspeed 80/90 knots $\pm$ 5 knots.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain constant ground track.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain rotor rpm 294 to 324 (339 maximum).	[]	[]	[]	[]	[]	[]	[]	[]

NIGHT LOW-LEVEL AUTOROTATION	Fits Poorly 1	2	Intermediate Degrees of Fit 3	4	5	6	7	Fits Well 8
Can perfectly maintain entry altitude as directed 50 feet (AHO).	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain entry airspeed 80/90 knots $\pm$ 5 knots.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain constant ground track.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain rotor rpm 294 to 324 (339 maximum).	[]	[]	[]	[]	[]	[]	[]	[]
NIGHT RECONNAISSANCE - HIGH, LOW AND GROUND								
High reconnaissance.								
1) Can perfectly maintain altitude as selected $\pm$ 100 feet.	[]	[]	[]	[]	[]	[]	[]	[]
2) Can perfectly maintain airspeed as selected $\pm$ 10 knots within the 60/70.	[]	[]	[]	[]	[]	[]	[]	[]
3) Area can be seen from selected altitude 100 percent.	[]	[]	[]	[]	[]	[]	[]	[]
4) Forced landing areas will be completely accessible when available.	[]	[]	[]	[]	[]	[]	[]	[]
Low reconnaissance can be completed.	[]	[]	[]	[]	[]	[]	[]	[]
NIGHT CIRCLING APPROACH								
Can perfectly maintain 200 feet AHO $\pm$ 100 feet.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly maintain 60/70 KIAS.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly perform varying rate of turn.	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly perform with a maximum 30 degree angle of bank.	[]	[]	[]	[]	[]	[]	[]	[]
NIGHT CONFINED-AREA OPERATION								
High reconnaissance completed (minimum 200 feet AHO).	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly perform circling approach.	[]	[]	[]	[]	[]	[]	[]	[]
Low reconnaissance completed.	[]	[]	[]	[]	[]	[]	[]	[]
Takeoff gas-producer N_1 not to exceed go-no-go limits.	[]	[]	[]	[]	[]	[]	[]	[]

NIGHT PINNACLE AND RIDGELINE OPERATIONS	Fits Poorly 1	2	Intermediate Degrees of Fit 3	4	5	6	7	Fits Well 8
High reconnaissance can be completed (minimum 200 feet AHO).	[]	[]	[]	[]	[]	[]	[]	[]
Can perfectly perform circling approach (approach angle 5-15 degrees).	[]	[]	[]	[]	[]	[]	[]	[]
Low reconnaissance can be completed.	[]	[]	[]	[]	[]	[]	[]	[]
Can achieve point of landing - inverted "Y".	[]	[]	[]	[]	[]	[]	[]	[]

APPENDIX B

STUDENT GRADE SHEET

DATE______________ STUDENT____________________ IP____________________

SIMULATOR TIME__________ UH-1 TIME TO SOLO__________ UH-1 TOTAL TIME__________

GRADING: 1 = low, unacceptable; 2 = low, acceptable; 3 = correct; 4 = hi, acceptable; 5 = hi, unacceptable; Y = yes; N = no; R = rough; S = smooth

TAKEOFF AND CLIMB

		TRIALS 1	2	3	4	5	6	7	8	9	10
ATTITUDE CONTROL	(Nose lo-to-hi)										
HEADING CONTROL	($\pm$ 10°)										
GROUND TRACK	(left-center-right)										
ESTAB. POS. RATE OF CLIMB	(Y - N)										
RATE OF CLIMB	(500fpm $\pm$ 100)										

SCORE	Last Sim. Flt	1	2	3	4	5	6	7	8	9	10	11	12
	First UH-1 Flt	1	2	3	4	5	6	7	8	9	10	11	12
	Last UH-1 Flt	1	2	3	4	5	6	7	8	9	10	11	12

CRUISE

	TRIALS 1	2	3	4	5	6	7	8	9	10
ALTITUDE ($\pm$ 50 ft)										
AIRSPEED ($\pm$ 10 kts)										

SCORE	Last Sim. Flt	1	2	3	4	5	6	7	8	9	10	11	12
	First UH-1 Flt	1	2	3	4	5	6	7	8	9	10	11	12
	Last UH-1 Flt	1	2	3	4	5	6	7	8	9	10	11	12

NIGHT APPROACH

		TRIALS 1	2	3	4	5	6	7	8	9	10
ENTRY											
ALTITUDE	($\pm$ 50 ft)										
AIRSPEED	($\pm$ 5 kts)										
APPROACH ANGLE	(shallow-to-steep)										
RATE OF CLOSURE	(slow-to-fast)										
TOUCHDOWN	(R - S)										

SCORE	Last Sim. Flt	1	2	3	4	5	6	7	8	9	10	11	12
	First UH-1 Flt	1	2	3	4	5	6	7	8	9	10	11	12
	Last UH-1 Flt	1	2	3	4	5	6	7	8	9	10	11	12

NIGHT AUTOROTATION		1	2	3	4	5	6	7	8	9	10
ENTRY ALTITUDE	(± 50 ft)										
ENTRY AIRSPEED	(± 5 kts)										
80 KT GLIDE ATTITUDE	(Y - N)										
AIRSPEED	(80 ± 5 kts)										
INITIAL DECELERATION ALTITUDE	(lo-correct-hi)										
AIRSPEED	(80 ± 5 kts)										
ATTITUDE CHANGE	(too little - correct-too much)										
INITIAL COLLECTIVE	(hesitant-correct-abrupt)										
COLLECTIVE CUSHIONING	(hesitant-correct-abrupt)										
TOUCHDOWN	(smooth - rough)										

TRIALS

SCORE													
SCORE	Last Sim. Flt	1	2	3	4	5	6	7	8	9	10	11	12
	First UH-1 Flt	1	2	3	4	5	6	7	8	9	10	11	12
	Last UH-1 Flt	1	2	3	4	5	6	7	8	9	10	11	12

TRIALS

NIGHT CONFINED AREA		1	2	3	4	5	6	7	8	9	10
CIRCLING APPROACH ALTITUDE	(± 50 ft)										
AIRSPEED	(± 10 kts)										
FINAL APPROACH LEG GROUND TRACK	(left-correct-right)										
APPROACH ANGLE	(8° - 15°)										
RATE OF CLOSURE	(slow-correct-fast)										
TOUCHDOWN	(smooth - rough)										

SCORE	Last Sim. Flt	1	2	3	4	5	6	7	8	9	10	11	12
	First UH-1 Flt	1	2	3	4	5	6	7	8	9	10	11	12
	Last UH-1 Flt	1	2	3	4	5	6	7	8	9	10	11	12

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